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(54) Corrosion inhibitors.

(57) Oligomers prepared by the reaction of an  $\alpha$ ,  $\beta$ -ethylenically unsaturated aldehyde with organic amines are thermally rearranged to give a more thermally stable product having labile amino hydrogens available for further reaction. The thermally rearranged oligomers by themselves or after reaction with a carboxylic acid, organic halide or an epoxide containing compound are useful as corrosion inhibitors. These corrosion inhibitors prevent the corrosion of metal caused upon exposure to corrosion of metal caused upon exposure to corrosive oil and gas well fluids.

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## CORROSION INHIBITORS

The present invention concerns new and useful corrosion inhibitors and in particular corrosion inhibitors which materially reduce the effects of attack of reactive materials on metals of construction.

5           In oil producing applications, metal tubing, sucker rods, valves, screens, coatings, pumps, and the like are subjected to the action of extremely corrosive fluids and gases. Such sweet and/or sour corrosive compositions can contain dissolved materials such as  
10   hydrogen sulfide, sulfur dioxide, carbon dioxide, oxygen, mineral acids, organic acids, and the like, as well as mixtures thereof.

Numerous processes for inhibiting the corrosion of metals caused upon exposure to corrosive oil and gas  
15   well fluids have been proposed. See, for example, U.S. Patents 2,643,977 and 3,077,454. Unfortunately, such processes are not effective under the conditions of high temperatures and pressures experienced by metal equipment in extremely deep oil and gas wells. Such conventional  
20   corrosion inhibitors can have a tendency to degrade,

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volatilize, or polymerize causing formation damage and/or inadequate corrosion protection.

In view of the deficiencies of the prior art, it would be highly desirable to provide a corrosion inhibitor which is easily prepared and can be effectively employed under very high temperature and pressure conditions.

The present invention concerns a new corrosion inhibitor composition comprising the thermally treated reaction product of (1) an  $\alpha,\beta$ -ethylenically unsaturated aldehyde and (2) an organic polyamine; wherein said thermal treatment is conducted at a temperature and for a time sufficient to provide an increase in thermal stability (as measured, for example, by differential scanning calorimetry) of at least about 25°C as compared to the thermal stability of the oligomer or polymer product prior to said thermal treatment. The product will generally be allowed to cool after its preparation. The reaction product is optionally further reacted with (3) a compound or compounds containing a group or groups capable of undergoing a reaction, quaternization or neutralization with an amine.

In another aspect, the present invention provides a method for preventing the corrosion of a metal composition in contact with down hole well fluids, which comprises contacting the surface of said metal composition with an effective amount of the aforementioned corrosion inhibitor. The present invention provides corrosion protection to metal compositions exposed to corrosive gases and/or fluids at high temperatures and pressures, such as are experienced in deep oil and gas wells.

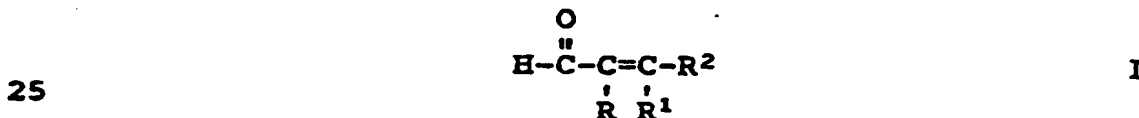
In another aspect, the present invention concerns a process for preparing an oligomer or polymer by first reacting (1) an  $\alpha,\beta$ -ethylenically unsaturated aldehyde

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and (2) an organic polyamine, which comprises the further step of heating the product at a temperature and for a time sufficient to provide an increase in thermal stability of at least about 25°C as compared to the thermal stability of the product of the first reaction step. Preferably, the reaction of (1) and (2) above is carried out in an inert solvent and at a temperature between about 0° and 150°C. The preferred molar ratio is polyamine (1) to aldehyde (2) of 1:0.5 to 1:1. Additionally, the reaction product of (1) and (2) above when desired can be further reacted with (3) a compound or compounds containing a group or groups capable of undergoing a reaction, quaternization or neutralization with an amine.

The corrosion inhibitors of the present invention act to protect metal compositions from corrosive effects of fluids and gases which are present in down hole well environments. Metal compositions typically include steel, iron, ferrous alloys, and other alloys of which typical sucker rods, valves and pumps are comprised.

The  $\alpha,\beta$ -ethylenically unsaturated aldehydes useful herein can be generally represented by the formula:



wherein each R, R<sup>1</sup> and R<sup>2</sup> are independently hydrogen, alkyl, aryl, aralkyl or substituted alkyl, aryl or aralkyl groups. Suitable substituents to the substituted alkyl, aryl or aralkyl groups include, for example, halo, alkoxy and amino groups. Examples of suitable  $\alpha,\beta$ -monoethylenically unsaturated aldehydes are disclosed in U.S. Patent 3,459,710. Other suitable aldehydes include, for

example, furfuryl, acrolein, -bromo or -chloro cinnamaldehyde, and hexenal. The preferred  $\alpha,\beta$ -ethylenically unsaturated aldehyde is acrolein, or mixtures thereof with other aldehydes.

5           The organic polyamines of this invention can include those organic diamines of the type disclosed in the aforementioned U.S. Patent 3,459,710 as well as those polyamines disclosed in U.S. Patent 4,292,413. Other polyamines include, for example, triethylenetetraamine, 10 tetraethylenepentamine, pentaethylenehexamine, polyoxypropyleneamine, iminobispropylamine, aminoethylethanolamine, and the like as well as mixtures thereof. In addition, monofunctional amines that can be utilized include diglycolamines, dodecylamine, cocoamine, hexa- 15 decylamine, octadecylamine, tallowamine, and the like. Of the foregoing polyamines, those polyamines containing at least one primary amine are preferred; with those polyamines capable of forming imidazolidine or hexahydropyrimidine moieties or substituted moieties thereof 20 being most preferred. Polyamines can be partially alkoxylated or partially polyalkoxylated so long as they contain at least one active amine hydrogen. Preferred polyamines are ethylenediamine and propylenediamine. Suitable polyamines also include the aminated 25 polyoxyalkylene polyols.

          The compounds comprising a functionality and/or functionalities capable of undergoing a reaction, quaternization or neutralization with an amine (i.e., substituent compounds) include, for example, compounds containing 30 carboxylic acid moieties, organic halide moieties, epoxide moieties, and the like. For example, a carboxylic acid moiety can react with an amine to form a salt, amide or

amidine-type linkage. Most preferably, substituent compounds include the polycarboxylic acids, organic polyhalides and polyepoxides. Such compounds are capable of introducing desired crosslinking to the product. Mono-

5 carboxylic acid compounds, organic monohalides and mono-epoxide compounds can be employed. Examples of suitable carboxylic acids include acetic acid, benzoic acid, phthalic acid, terephthalic acid, octanoic acid, myristic acid, palmitric acid, oleic acid, isostearic acid, capric

10 acid, caprylic acid, lauric acid, tall oil fatty acids, naphthenic acids, dimer acids, trimer acids and similar mono- and poly- carboxylic acids. Other suitable acids are disclosed in U.S. Patent 4,339,349. Examples of suitable organic halides are disclosed in U.S.

15 Patent 4,315,087. Examples of suitable mono- and poly-epoxides include epoxidized vegetable oils such as epoxidized linseed oil, epoxidized carboxylic acids such as epoxidized oleic acid, the glycidyl ethers, and the like. Other suitable epoxide compounds are disclosed in

20 U.S. Patent 4,292,413. Other suitable compounds having a functionality or functionalities capable of undergoing a reaction, quaternization or neutralization with an amine include, for example, inorganic acids, aldehydes, alkylene oxides, cyanides, nitriles, sulfur containing compounds

25 such as mercaptans, and the like. Preferably, the substituent compound has a predominantly hydrophobic character.

Products used in this invention are preferably prepared by first reacting the organic polyamine with the  $\alpha,\beta$ -ethylenically unsaturated aldehyde. Preferably, the

30 reaction is carried out in an inert solvent and at a temperature between about 0°C and about 150°C. The choice of inert solvent is generally dependent upon the boiling point of the polyamine, the solubility of the polyamine and the solubility of the resulting oligomer or polymer.

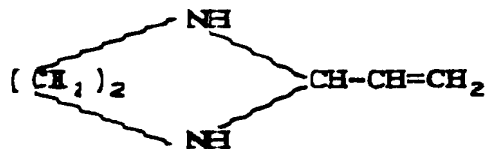
Advantageously, the solvent is one in which both the monomers and resultant oligomer are soluble. Suitable solvents include methanol, ethanol, butanol, benzene, water, dioxane, dimethylformamide, tetrahydrofuran, and  
5 the like.

Preferably one mole of polyamine is reacted with 0.5 to 1.0 mole of unsaturated aldehyde. Preferably, the organic polyamine is dissolved in a suitable solvent in a reaction vessel. A solution of the unsaturated aldehyde  
10 and suitable solvent is then reacted with the polyamine solution, preferably in a slow manner. The reaction mixture can be cooled or heated. Solvent can be removed by distillation. Preferably, a solvent, such as  
15 isopropanol can be added to the reaction mixture in order to create an azeotropic mixture for removing solvent and by-product.

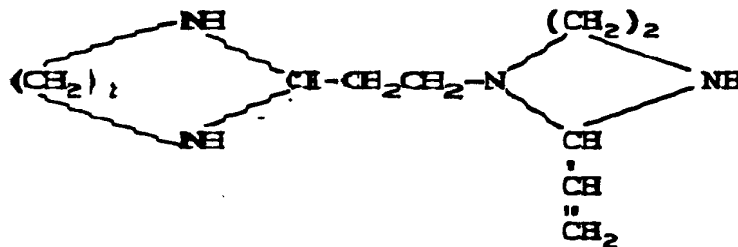
Oligomer or polymer products usually have an average molecular weight less than about 1,000 and are obtained from the reaction of  $\alpha,\beta$ -ethylenically  
20 unsaturated aldehydes with organic polyamines. The oligomers or polymers within the scope of this invention comprise compounds that can comprise vinyl, imine, enamine, ether, and hydroxyl functional groups. The reaction of an amine containing piperazine rings with an  $\alpha,\beta$ -ethylenically  
25 unsaturated aldehyde introduces piperazine rings into the constituents of the product. The reaction of the carbonyl of  $\alpha,\beta$ -monoethylenically unsaturated aldehyde with a primary amine forms an imine which readily cyclizes if labile (where the term "labile" is as defined in U.S.  
30 Patent 4,315,087) amine hydrogens are available, preferably in the  $\gamma$  or  $\delta$  position relative to the nitrogen of the imine. An imidazolidine ring is formed from the

reaction of the carbonyl of an  $\alpha, \beta$ -monoethylenically unsaturated aldehyde with an ethylenepolyamine while a hexahydropyrimidine ring is formed from the reaction of the carbonyl of an  $\alpha, \beta$ -monoethylenically unsaturated aldehyde with a propylenepolyamine. Some of the possible constituents of the oligomers formed from the reaction of, for example, acrolein with ethylenediamine are believed to be represented by the following structures:

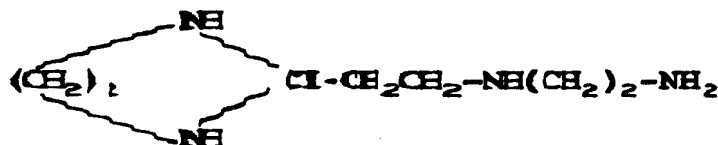
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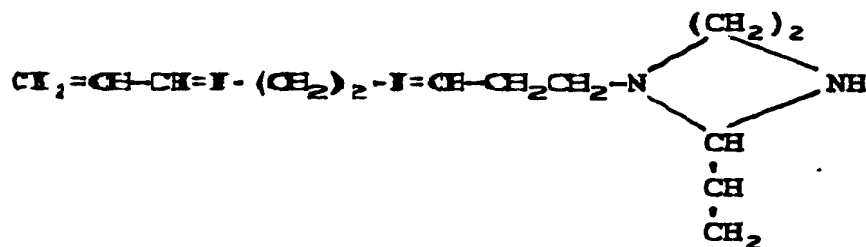
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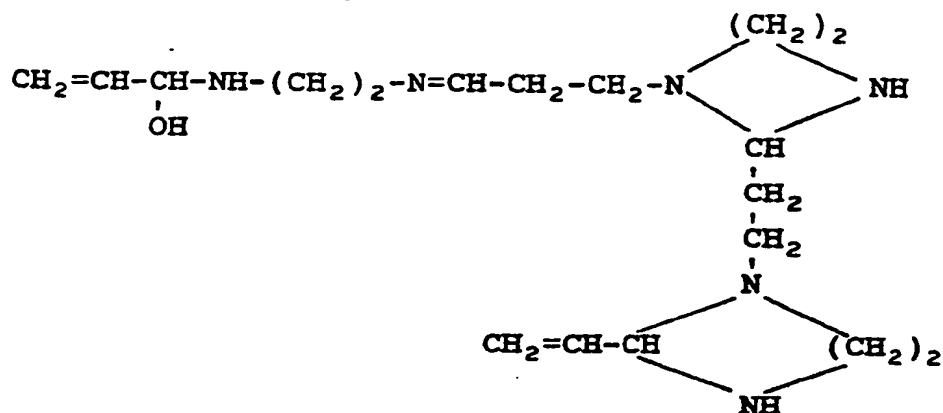


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and





The thermal treatment is usually conducted by heating the oligomer or polymer from the reaction of  $\alpha, \beta$ -ethylenically unsaturated aldehyde with an organic polyamine while stirring in air or an inert atmosphere such as, for example, nitrogen, helium, neon, xenon, argon, mixtures thereof and the like. The temperature required to achieve the increase in thermal stability depends upon the particular oligomer or polymer being treated. However, a temperature of at least about 170°C, preferably from about 190°C to about 350°C is usually required. In some instances, lower temperatures could produce the desired increase in thermal stability. The oligomer or polymer is heated for a period of time to sufficiently rearrange the original oligomers or polymers such that the resultant product has an increase in thermal stability of at least 25°C above that of the product prior to heat treatment. The period of time in which the oligomer or polymer is heated can range from about 10 minutes to about 48 hours. The preferred period of time for thermally rearranging the oligomer or polymer is 30 minutes to 2 hours. In the case where the oligomer or polymer results from the reaction of acrolein with an ethylenepolyamine, pyridines and pyrazines having methyl substituents are formed and are evolved or reside with

the final product. Generally, the thermally rearranged oligomer or polymer is more thermally stable than the original oligomer or polymer. The preferred atmosphere for stirring the oligomer or polymer during thermal  
5 rearrangement is nitrogen.

The product which is isolated optionally can be contacted with the compound comprising a functionality or functionalities capable of undergoing a reaction, quaternization or neutralization with an amine. The previously  
10 described product is dissolved or dispersed in a suitable solvent and contacted with the substituent compound which is also dissolved in a suitable solvent. The amount of substituent compound which is employed can vary such that about 1 to about 100 percent of the available amino  
15 hydrogens of the polyamine/unsaturated aldehyde product can be reacted with reactive functionalites of the substituent compound. This resulting product can, if desired, be isolated using techniques such as distillation to remove by-products and solvent.

20 The resulting thermally treated product can be employed as a corrosion inhibitor, such as those corrosion inhibitor formulations known in the art. For example, when desired the product can be dispersed or dissolved in a suitable carrier, liquid or solvent such as water,  
25 alcohols, aromatic and aliphatic hydrocarbons, and the like, or mixtures thereof. Other additives include demulsifiers, water wetting agents, surfactants, viscosifiers, commingled gases, defoamers, other corrosion inhibitors such as polymeric materials and salts, organic  
30 and inorganic acids, iron control agents, sequestering and/or chelating agents, phosphates, quaternaries, amine salts, and the like. For example, surface active agents are used to assure complete dispersion of active ingredients

throughout the corrosion inhibitor composition and thus provide a better contact of the corrosion inhibitor with the surface of the metal compound which is being protected. The corrosion inhibitors of this invention form films on  
5 metal surfaces at least as readily as those known film  
- forming corrosion inhibitors.

The corrosion inhibitor of this invention is employed in a functionally effective amount. That is, any quantity of corrosion inhibitor which will provide  
10 some degree of inhibition of corrosion is sufficient. Typical amounts of corrosion inhibitor which are employed in an oil and/or gas well treatment can range from about 5 to about 2,000 ppm for continuous treatment or about 1,000 to about 50,000 ppm for squeeze treatment, based on  
15 the weight of corrosive well fluids in contact with the metal compositions which are protected. Amounts of corrosion inhibitor in excess of 50,000 ppm can provide additional corrosion inhibition but at increased expense.

The corrosion inhibitors of this invention are  
20 highly stable to high temperatures and high pressures. Typically, corrosion inhibitors are employed in applications where temperatures range from about 100°F (about 40°C) to in excess of about 500°F (about 260°C), depending upon the composition of the polymer product. The corrosion  
25 inhibitors of this invention are especially useful at temperatures ranging from about 300°F (about 150°C) to about 450°F (about 230°C).

The corrosion inhibitors of this invention inhibit corrosion to metal compositions used in down hole  
30 applications, preferably in excess of 80 percent corrosion protection. The corrosion inhibitors advantageously inhibit corrosion to metal compositions at elevated

temperatures exceeding about 250°F (about 120°C) in oil and gas well applications. Useful applications include oil and/or gas well drilling, completion, workover, stimulation, transfer, processing and storage applications.

5           The following examples are presented to further illustrate, but not limit, the scope of this invention.

EXAMPLE 1

A. PREPARATION OF ACROLEIN/ETHYLENEDIAMINE OLIGOMER AT A MOLAR RATIO OF 1/1 RESPECTIVELY

10           Acrolein is distilled in the presence of 358 ppm and 379 ppm of hydroquinone in the boiling and receiving flasks, respectively. A solution of distilled acrolein was prepared by mixing 282.1 grams (g) (5 moles) acrolein with about 155 g methanol.

15           Into a reactor equipped with stirrer, thermometer, condensor, and addition funnel with nitrogen inlet tube was placed a solution of 300 g (5 moles) ethylenediamine and about 510 g methanol. The reactor contents were stirred under nitrogen atmosphere while  
20 being held at a temperature of about 4°C.

          The acrolein solution was added to the reactor over a period of 160 minutes (9600 s) at such a rate that the rise in temperature did not exceed 23°C. The mixture was subjected to rotary evaporation at 100°C. An amount  
25 of isopropanol was added to the mixture and said mixture was again subjected to rotary evaporation at 100°C. The product was a yellowish viscous liquid.

B. THERMAL TREATMENT OF OLIGOMER

          Into a one liter reactor equipped with a  
30 condensing assembly, stirrer, thermometer, addition

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funnel, and nitrogen inlet tube was placed 210 g of the oligomer product from A above. The condensing assembly consisted of a Dean Stark trap, cold water condenser and dry ice-acetone cold finger. The reactor contents were stirred under nitrogen atmosphere at 125°C for 60 minutes (3600 s). Then the reactor contents were heated at 10°C increments at 60 minute intervals up to 250°C. Overhead and bottom samples were caught at each 10°C interval.

Infrared spectra of the bottom sample indicated the oligomer product had undergone thermal rearrangement. The infrared spectra at 125°C showed bands at 1655, 1630 and 1600  $\text{cm}^{-1}$ . The band at 1655  $\text{cm}^{-1}$  was assigned to C=N stretch. The absorption at 1630  $\text{cm}^{-1}$  was attributed to C=C stretch. The absorption at 1655 and 1630  $\text{cm}^{-1}$  increased upon heating the polymer product up to 190°C. Above 190°C, the band at 1600  $\text{cm}^{-1}$  was the predominant absorption of the three bands.

The infrared spectra at 125°C also showed absorption bands at 3270, 2940, 2800, 1260 and 900  $\text{cm}^{-1}$ . The absorption band at 3270  $\text{cm}^{-1}$  was assigned to N-H stretching vibration of a secondary amine. Above 190°C a broad absorption band at 3400  $\text{cm}^{-1}$  replaced the 3270  $\text{cm}^{-1}$  band. The absorption bands at 2940 and 2800  $\text{cm}^{-1}$  were assigned to C-H stretch. At 125°C, these bands were of similar intensity. Above 190°C, the band at 2940  $\text{cm}^{-1}$  was slightly more intense than the band at 2800  $\text{cm}^{-1}$ . Above 190°C, the absorptions at 1260 and 900  $\text{cm}^{-1}$  disappeared.

Overhead samples collected in the Dean Stark trap were analyzed by electron impact mass spectroscopy. Methylpyridine was identified only in overhead samples collected at and above 135°C. Ethanamine, pyrazine,

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methypyrazine, ethypyrazine, dimethylpyridine, ethylpyridine, trimethylpyridine, and ethylmethypyridine were identified along with methylpyridine in the overhead fraction collected at 250°C.

5           The reactor bottom samples were analyzed with methane chemical ionization probe mass spectroscopy.  $[M+1]^+$  fragments corresponding to the molecular weight of methylpyridine were observed only in the bottom samples collected at and above 170°C.  $[M+1]^+$  fragments corresponding to the molecular weights of C<sub>2</sub>-pyrazine, C<sub>3</sub>-pyrazine, C<sub>4</sub>-pyrazine and C<sub>5</sub>-pyrazine were present in addition to that corresponding to methylpyridine in the bottom samples collected at and above 180°C. The bottom sample collected at 250°C was a dark brown hard solid at room temperature that had a distinct pyridine odor.

          The number average molecular weight (Mn) and weight average molecular weight (Mw) of the thermally treated product was determined by gel permeation chromatography with methanol as the eluent. Monoethylene glycol and E-200 polyglycol served as standards. Between 125°-190°C, the Mn varied between 196-235 and the Mw varied between 394-423. Between 200°-250°C, the Mn varied between 100-130 and Mw varied between 234-280.

#### EXAMPLE 2

##### 25   A. PREPARATION OF ACROLEIN/MIXTURE OF TETRAETHYLENEPENTAMINE, PENTAETHYLENEHEXAMINE, HEXAETHYLENEHEPTAMINE OLIGOMER

          Into a jacketed reactor equipped with a mechanical stirrer, thermometer, condenser, and addition funnel is placed a solution containing 771 grams (3.15 moles) of a polyalkylene polyamine product having an average molecular weight higher than tetraethylenepentamine (commercially

available from The Dow Chemical Company as Ethyleneamine E-100) and 495 grams of anhydrous methanol. The reactor contents were stirred under nitrogen atmosphere while cooled to 3°C. A solution of distilled acrolein was prepared by mixing 282 grams (5.03 moles) of acrolein with 323 grams of anhydrous methanol. The acrolein solution was added to the reactor using an addition funnel over a period of 250 minutes (15000 s). After reaction completion, the mixture was subjected to rotary evaporation at 100°C. An amount of isopropanol was added to the mixture and again subjected to rotary evaporation. The resultant product was an amber colored viscous liquid.

#### B. THERMAL TREATMENT OF OLIGOMER

Into a one liter reactor equipped with a condenser assembly, mechanical stirrer, nitrogen inlet tube, and thermometer was placed 139 grams of the oligomer product from A above. The condenser assembly consisted of a Dean Stark trap and chilled glycol condenser. The reactor contents were stirred under the nitrogen atmosphere at 100°C for 1 hour (3600 s). The reactor contents were heated incrementally at 60 minute intervals to 350°C. Overhead and bottom samples were caught at each interval.

Overhead samples collected in the Dean Stark trap were analyzed by electron impact mass spectroscopy. Methylpyridine, ethylpyridine, dimethylpyridine and methylethylpyridine were identified in the overhead fractions collected between 150° and 300°C. Methylpyridine was the most concentrated of these constituents. Dimethylpyrazine, methylethylpyrazine and C<sub>4</sub>-pyrazine were identified in the overhead fractions collected at and above 300°C.

EXAMPLE 3THERMAL STABILITY

The thermal stability of the products of this invention were determined by differential scanning calorimetry (DSC) scan of various samples using a DuPont Model 1090 Thermoanalyzer. In the differential scanning calorimetry analysis, the samples were placed in an aluminum pan and programmed from 25° to 500°C at 10°C/min. with a nitrogen purge. The samples tested were the thermally rearranged acrolein/ethylenediamine oligomers and the acrolein/mixture of tetraethylenepentamine, pentaethylenehexamine and hexaethyleneheptamine oligomers prepared as described in Examples 1 and 2, respectively. Results for the thermally rearranged acrolein/ethylenediamine oligomers prepared in Example 1 are given in Table I.

TABLE I

	<u>Thermal Treatment Temperature</u>	<u>Initial Decomposition DSC</u>
20	NONE*	200°C
	125*	160°C
	135*	150°C
	160*	200°C
	170*	210°C
25	180	280°C
	250	300°C

\*Not an example of this invention.

Results for the thermally rearranged acrolein/-mixture of tetraethylenepentamine, pentaethylenehexamine,



and hexaethyleneheptamine oligomers as prepared in Example 2 are given in Table II.

TABLE II

5	Thermal Treatment <u>Temperature</u>	Initial Decomposition <u>DSC</u>
	NONE*	150°C
10	100*	160°C
	110*	160°C
	140*	160°C
	160*	170°C
	180*	150°C
	240	250°C
	250	250°C
15	280	230°C
	300	200°C
	325	220°C
	350	220°C

\*Not an example of this invention.

20 EXAMPLE 4

CORROSION TESTING, 175°F (79.4°C)

The thermally treated products from Examples 1B and 2B were tested for their corrosion inhibition properties by the following procedure.

25 Corrosion inhibition of various samples was determined under conditions which simulate conditions that exist in oil and gas wells as follows. A brine solution containing 89.89 percent deionized water,

9.62 percent sodium chloride, 0.305 percent calcium chloride and a 0.186 percent hydrated magnesium chloride complex was prepared. This brine solution was saturated under carbon dioxide purge until a pH of 3.8 was achieved.

5 The solution was treated with sodium persulfate to remove oxygen. The desired corrosion inhibitor was added to the solution. About 720 milliliters (ml) of this brine solution and 80 ml of kerosene treated with sodium persulfate were charged into a 32-ounce bottle. To this

10 charge was added enough hydrated sodium sulfide to generate a suitable amount of hydrogen sulfide (i.e., about 300 ppm hydrogen sulfide based on total fluids).

Metal coupons of 1020 carbon steel were degreased with an inhibited methylchloroform, acidized

15 with 16 percent hydrochloric acid, washed and dried. Each coupon weighed about 19 g. A metal coupon was placed in the bottle containing the brine, kerosene and ingredients as previously described. The bottle was capped and acetic acid was injected into the bottle through a septum. The

20 bottle was placed on a vertically rotating wheel held at 175°F (79.3°C) and the sample was rotated at 26 rpm for 24 hours (86400 s). The coupons were removed from the bottle, cleaned, washed, dried and reweighed and the percent protection afforded them by the inhibitor is

25 calculated as the percent protection by the following formula:

$$\text{percent protection} = 100 - \frac{\text{inhibitor coupon wt. loss}}{\text{blank coupon wt. loss}} \times 100$$

The weight loss is given to the nearest whole

30 percent. The tests wherein no inhibitor is employed are for comparative purposes and are designated as blanks.

The corrosion rates are also determined in millinches per year (mpy) corrosion rates by the following formula:

$$5 \quad \text{mpy} = \frac{534 \text{ (Mg Weight Loss of Coupon)}}{d \times a \times t}$$

d = density of 1020 carbon steel = 7.86 g/ml  
a = surface area (in.) of metal coupons  
t = test time in hours

10 The amount of corrosion of untreated coupons was compared to coupons which were tested in the presence of 100 ppm of each corrosion inhibitor sample. Results are presented in Table III for the thermally rearranged acrolein/ethylenediamine oligomers prepared in Example 1-B.

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TABLE III

	INHIBITOR		Weight Loss grams	Percent Protection	MPY**
	Product From Heat Treatment at Indicated Temperature °C	Concentration ppm			
5	No Inhibitor*	0	0.1879	0	71.0
	No Heat Treat- ment*	100	0.0351	81.3	13.3
10	125*	100	0.0357	81.0	13.9
	135*	100	0.0402	78.6	15.7
	150*	100	0.0344	81.7	13.9
	162*	100	0.0325	82.7	12.5
15	170*	100	0.0261	86.1	10.8
	180	100	0.0381	83.2	13.0
	190	100	0.0477	74.6	16.8
	200	100	0.0309	83.6	12.6
	250	100	0.0423	77.5	14.8

20 \*Not an example of this invention.  
 \*\*MPY is mils per year.

25 Results are presented in Table IV for the  
 thermally rearranged acrolein/mixture of tetraethylene-  
 pentamine, pentaethylenehexamine, and hexaethylenehepta-  
 mine oligomers prepared in Example 2-B.

TABLE IV

	INHIBITOR		Weight Loss grams	Percent Protection	MPY**
	Product From Heat Treatment at Indicated Temperature °C	Concentration ppm			
5	No Inhibitor*	0	0.2804	0	109.8
10	No Heat Treat- ment*	100	0.0394	81.2	15.2
	100*	100	0.0720	74.3	28.0
	110*	100	0.0621	77.9	24.1
	140*	100	0.0862	69.3	33.5
	160*	100	0.0844	69.9	32.7
15	No Inhibitor*	0	0.2439	0	9.37
	180*	100	0.0389	84.1	15.0
	192	100	0.0328	86.6	12.7
	250	100	0.0257	89.5	9.9
20	No Inhibitor*	0	0.2412	0	92.6
	280	100	0.0687	71.5	26.6
	300	100	0.0490	79.7	19.1
	325	100	0.0388	83.9	15.1
	350	100	0.0446	81.5	17.0

\*Not an example of this invention.

25 \*\*MPY is mils per year.

#### EXAMPLE 5

#### PREPARATION OF ACROLEIN/ETHYLENEDIAMINE/WESTVACO DIACID 1550

30 Acrolein/ethylenediamine oligomers thermally rearranged at 250°C (49.99 g) from example 1-B, Westvaco Diacid 1550 (76.91 g) and isopropanol (126.27 g) were weighed into a one liter 5 neck round bottom flask equipped with a condensing assembly, stirrer, thermometer and

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nitrogen inlet tube. The reactor contents were refluxed at 82°C for 1 hour (3600 s). A barrett trap was attached to the reactor. One hour and eleven minutes (4260 s) later, all isopropanol had been removed by using the  
5 barrett trap. The reactor contents were heated at 210°C for 2 hours 19 minutes (8340 s). Reactor contents (121.02 g) were cooled to less than 60°C and then dissolved in isopropanol (196.45 g). This isopropanol solution was refluxed at 82°C for 1 hour and 10 minutes (4200 s).

10 EXAMPLE 6

PREPARATION OF ACROLEIN/ETHYLENEDIAMINE/1-BROMOOCTADECANE

Acrolein/ethylenediamine oligomers thermally rearranged at 250°C (23.06 g) from Example 1-B, and 1-bromooctadecane (66.74 g) were weighed into a 500 ml  
15 resin kettle equipped with a condensing assembly, stirrer, thermometer and nitrogen inlet tube. The reactor contents were heated at 90°C for 15 minutes (900 s) and then cooled to room temperature. 150 ml xylene (181.54 g) was added to reactor contents. Reactor contents were maintained  
20 at 75°C for 35 minutes (2100 s). Reactor contents were heated between 60°-110°C for 2 additional hours (7200 s).

EXAMPLE 7

PREPARATION OF ACROLEIN/TETRAETHYLENE PENTAMINE, PENTAETHYLENE HEXAMINE, HEXAETHYLENE HEPTAMINE/1-BROMO-OCTADECANE

25 Acrolein/mixture of 14 area percent tetraethylenepentamine, 42 area percent pentaethylenhexamine and 27 area percent hexaethylenheptamine oligomers thermally rearranged at 250°C (20.8 grams) from Example 2-B, 1-bromo-  
30 octadecane (74.1 grams) and isopropanol (31.6 grams) were weighed into a reactor of the type described in Example 7. Area percent was determined by gas chromatography. The reactor contents were stirred at 82.5°C for one hour

(3600 s). Isopropanol was removed at 90°C by using a Dean Stark trap.

#### EXAMPLE 8

##### CORROSION TESTING

5                   The corrosion inhibitors prepared in Examples 5, 6 and 7 were tested employing the procedure of Example 4. The results are given in Table V.

TABLE V

10	<u>INHIBITOR</u>	<u>Concentration</u> <u>ppm</u>	<u>Weight</u> <u>Loss</u> <u>grams</u>	<u>Percent</u> <u>Protection</u>	<u>MPY</u>
	None*	0	0.2725	0	105.2
	Example 5	100	0.0328	88	12.3
	Example 6	100	0.0281	90	10.8
15	None*	0	0.1700	0	65.5
	Example 7	100	0.0178	89.5	6.8

\*Not an example of this invention.

20                   The data in Table V demonstrates that thermally rearranged  $\alpha,\beta$ -unsaturated aldehyde/amine oligomers reacted with a fatty carboxylic acid or organic halide exhibits excellent corrosion protection under simulated down hole tests at 175°F.

#### EXAMPLE 9

##### CORROSION TESTING, 350°F (177°C)

25                   The performance of 100 ppm of a corrosion inhibitor sample also was tested in a 24 hour 350°F (177°C) wheel test containing 90 percent brine/8 percent heptane/-2 percent kerosene at 2,000 psi pressure (25°C) with

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10 percent hydrogen sulfide, 10 percent carbon dioxide and 80 percent methane in a stainless steel pipe bomb. Results are presented in Table VI for the corrosion inhibitors prepared in Examples 5, 6 and 7.

5

TABLE VI

<u>Inhibitor</u>	<u>Concentration ppm</u>	<u>Weight Loss grams</u>	<u>Percent Protection</u>	<u>MPY</u>
None	0	0.1443	0	135.0
10 Example 5	100	0.0382	74	35.7
Example 6	100	0.0311	79	29.1
Example 7	100	0.0289	80	27.0

The data in Table VI demonstrates that thermally rearranged  $\alpha, \beta$ -unsaturated aldehyde/amine oligomers reacted with a fatty carboxylic acid or organic halide exhibits good corrosion protection under simulated down hole tests at 350°F.

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CLAIMS

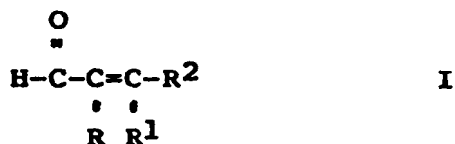
1. A corrosion inhibitor prepared by heat treating the reaction product of
  - (A) alpha beta-ethylenically unsaturated  
05 aldehyde, and
  - (B) an organic polyamine;at a temperature and for a time sufficient to provide an increase in thermal stability of at least about 25°C as compared to the thermal stability of the said  
10 reaction product prior to said heat treatment.
2. A corrosion inhibitor prepared by heat treating the reaction product of
  - (A) an alpha beta-ethylenically unsaturated  
aldehyde, and
  - 15 (B) an organic polyamine;and thereafter allowing the product to cool, wherein said thermal treatment is conducted at a temperature and for a time sufficient to provide an increase in thermal stability of at least about 25°C as compared  
20 to the thermal stability of the said reaction product prior to said heat treatment.
3. A corrosion inhibitor prepared by heat treating the reaction product of
  - (A) an alpha beta-ethylenically unsaturated  
25 aldehyde, and
  - (B) an organic polyamine;

wherein said thermal treatment is conducted at a temperature and for a time sufficient to provide an increase in thermal stability (measured by differential scanning calorimetry) of at least about 05 25°C as compared to the thermal stability of the reaction product prior to said thermal treatment.

4. A corrosion inhibitor as claimed in any one of claims 1 to 3 wherein the polyamine is capable of forming imidazolidine moieties or hexahydropyrimidine 10 moieties, or substituted moieties thereof.

5. A corrosion inhibitor as claimed in any one of claims 1 to 3 wherein the polyamine is a partially ethoxylated or a partially polyethoxylated polyamine or an aminated polyoxyalkylene polyol.

15 6. A corrosion inhibitor as claimed in any one of claims 1 to 3 wherein the alpha beta-ethylenically unsaturated aldehyde has the formula:



wherein each R, R<sup>1</sup> and R<sup>2</sup> are independently hydrogen, alkyl, aryl, aralkyl or substituted alkyl,

aryl or aralkyl groups.

7. A corrosion inhibitor as claimed in any one of claims 1 to 3 wherein the aldehyde is acrolein and the polyamine is ethylenediamine.

05 8. A corrosion inhibitor as claimed in any one of claims 1 to 3 wherein said aldehyde is acrolein and said polyamine is a mixture of tetraethylenepentamine, pentaethylenehexamine and hexaethyleneheptamine.

9. A corrosion inhibitor as claimed in any of the  
10 preceding claims, wherein said thermal treatment is conducted at a temperature of from about 190°C to about 350°C.

10. A corrosion inhibitor as claimed in any of the preceding claims, wherein the available amino  
15 hydrogens of the thermally treated product are further reacted with at least one compound containing a group or groups capable of undergoing a reaction, quaternization, or neutralization with an amine.

11. A corrosion inhibitor as claimed in Claim 10  
20 wherein the compound or compounds containing a group or groups capable of undergoing a reaction, quaternization or neutralization with an amine is a carboxylic acid, organic halide or organic epoxide.

12. A corrosion inhibitor as claimed in Claim 10  
25 wherein the compound or compounds containing a group or groups capable of undergoing a reaction,

quaternization or neutralization with an amine is a polycarboxylic acid, a polyepoxide or an organic polyhalide.

13. A corrosion inhibitor as claimed in Claim 10  
05 wherein the compound or compounds containing a group or groups capable of undergoing a reaction, quaternization or neutralization with an amine is a mixture of at least one monocarboxylic acid and at least one dicarboxylic acid.
- 10 14. A corrosion inhibitor as claimed in Claim 10 wherein the compound or compounds containing a group or groups capable of undergoing a reaction, quaternization or neutralization with an amine is a liquid monocyclic dicarboxylic acid having from about  
15 21 to about 24 carbon atoms.
15. A corrosion inhibitor as claimed in Claim 10 wherein the compound or compounds containing a group or groups capable of undergoing a reaction, quaternization or neutralization with an amine is  
20 1-bromooctadecane.
16. A corrosion inhibiting composition, comprising a corrosion inhibitor as claimed in any one of the preceding claims, together with a suitable carrier.
17. A composition as claimed in Claim 16 wherein the  
25 carrier is water, an alcohol or an aromatic or aliphatic hydrocarbon.

18. A composition as claimed in any one of the preceding claims which also comprises one or more of demulsifiers, water wetting agents, surfactants, viscosifiers, commingled gases, defoamers or other corrosion inhibitors.
19. A method for preventing the corrosion of a metal composition in contact with a down hole well fluid, which process comprises contacting the surface of said metal composition with an effective amount of a composition as claimed in any one of Claims 16 to 18.
20. A method for preventing the corrosion of a metal composition in contact with a down hole well fluid, which process comprises introducing a corrosion inhibitor or claimed in any one of Claims 1 to 15, or a composition as claimed in any one of Claims 16 to 18 into the down hole well fluid.
21. A method as claimed in Claim 19 wherein said effective amount of corrosion inhibitor is from about 5 to about 2,000 ppm, based on the weight of said well fluid in contact with said metal composition.
22. A process for preparing a heat treated oligomer or polymer which method comprises reacting (1) an -ethylenically unsaturated aldehyde and (2) an organic polyamine, and heat treating the produce at a temperature and for a time sufficient to provide an increase in thermal stability of at least about 25°C

as compared to the thermal stability of the product of the first reaction step.

23. A process as claimed in Claim 22, wherein the heat treated oligomer or polymer product is further  
05 reacted with at least one compound containing a group or groups capable of undergoing a reaction, quaternization, or neutralization with an amine.

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**EUROPEAN PATENT APPLICATION**

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⑥④ **Corrosion inhibitors.**

⑥⑦ Oligomers prepared by the reaction of an  $\alpha,\beta$ -ethylenically unsaturated aldehyde with organic amines are thermally rearranged to give a more thermally stable product having labile amino hydrogens available for further reaction. The thermally rearranged oligomers by themselves or after reaction with a carboxylic acid, organic halide or an epoxide containing compound are useful as corrosion inhibitors. These corrosion inhibitors prevent the corrosion of metal caused upon exposure to corrosive oil and gas well fluids.

**EP 0 188 353 A3**



European Patent  
Office

# EUROPEAN SEARCH REPORT

0188353

Application number

EP 86 30 0181

## DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl 4)
A, D	US-A-3 459 710 (R.J. CAIOLA et al.) * Claims 1-5; column 3, lines 16-20 *	1-3, 5, 7	C 23 F 11/173 E 21 B 41/02
A	US-A-4 315 087 (D. REDMORE et al.) * Claims 1, 4, 6; column 8, line 60 - column 9, line 59 *	1-23	
A	US-A-3 770 377 (R.H. SCOTT et al.) * Claims 1, 2 *	1	
A	US-A-3 932 296 (N.J. BYTH)		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl 4)  C 23 F 11/00 E 41 B 41/00
Place of search THE HAGUE		Date of completion of the search 19-03-1987	Examiner DE ANNA P.L.
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